I, Kenji Takaishi, declare as follows:

1. I am a citizen of Japan residing at 5-1-615, Higashiikebukuro 4-chome, Toshima-ku, Tokyo, Japan.

2. To the best of my ability, I translated relevant portions of:

Japanese Patent Application No. 2003-413623

from Japanese into English and the attached document is a true and accurate abridged English translation thereof.

3. I further declare that all statements made herein are true, and that all statements made on information and belief are believed to be true; and further that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: July 17, 2008

Kenji Takaishi

Kenji Takaishi

**Japanese Patent Application No. 2003-413623**

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|---|---|
| **Document** | Application for Patent |
| **Ref. No.** | TR03038 |
| **To:** | Commissioner of The Patent Office |
| **IPC** | H01P 1/15 |

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**Application Fee**

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| Account No. | 010375 |
| Amount | 21000 |

**Attached Papers**

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| Claims | one |

| | |
|---|---|
| Specification | one |
| Drawings | one |
| Abstract | one |

# SPECIFICATION

# HIGH-FREQUENCY CIRCUIT, HIGH-FREQUENCY COMPONENT AND MULTI-BAND COMMUNICATION APPARATUS USING SAME

## FIELD OF THE INVENTION

[0001] The present invention relates to a wireless communication apparatus for performing wireless transmission between electronic or electric equipments, particularly to a high-frequency circuit and a high-frequency component commonly usable for at least two communication systems and capable of conducting diversity receiving, and a multi-band communication apparatus comprising such a multi-band high-frequency circuit component.

## BACKGROUND OF THE INVENTION

[0002] Data communications by wireless LAN (WLAN) typically according to the IEEE802.11 standards are now widely used. They are used in personal computers (PCs); PC peripherals such as printers, hard disk drives, broadband rooters, etc.; electronic appliances such as facsimiles, refrigerators, standard-definition televisions (SDTVs), high-definition televisions (HDTVs), digital cameras, digital video recorders, cell phones, etc.; and as signal-transmitting means in place of wires in automobiles and aircrafts, and wireless data transmission is conducted among these electronic or electric appliances. There are now pluralities of standards of wireless LAN. For instance, IEEE802.11a is

adapted to high-speed data communications of 54 Mbps at maximum in a frequency band of 5 GHz, using an OFDM (orthogonal frequency division multiples) modulation system. IEEE802.11b is adapted to high-speed communications of 5.5 Mbps and 11 Mbps in an industrial, scientific and medical (ISM) band of 2.4 GHz that can be freely used without wireless license, using a direct sequence spread spectrum (DSSS) system. IEEE802.11g is adapted to high-speed data communications of 54 Mbps at maximum in a 2.4-GHz band like IEEE802.11b, using the OFDM (orthogonal frequency division multiples) modulation system. Explanation will be made below using IEEE802.11a as a first communication system, and IEEE802.11b and IEEE802.11g as a second communication system, if necessary.

[0003] A multi-band communication apparatus using such WLAN is described in Japanese Patent Laid-Open No. 2003-169008. This multi-band communication apparatus comprises two dual-band antennas capable of transmitting and receiving in two communication systems having different communication frequency bands (IEEE802.11a, IEEE802.11b), two transmitting/receiving means for modulating transmission data and demodulating receiving data in each communication system, pluralities of switch means for connecting the antennas to the transmitting/receiving means, and switch control means for controlling the switch means, so that it can perform diversity receiving (see Fig. 18).

OBJECTS OF THE INVENTION

[0004] This multi-band communication apparatus scans the frequency

to sense the receivable frequency channel before starting communications. When this scanning operation is conducted, the antenna ANT1 is connected to a receiving terminal Rx of the transmitting/receiving means of 802.11a, and the antenna ANT2 is connected to a receiving terminal Rx of the transmitting/receiving means of 802.11b, by six single-pole, double-throw (SPDT) switch means (SW1-SW6). The transmitting/receiving means of 802.11a is scanned in a 5-GHz band, and the transmitting/receiving means of 802.11b is scanned in a 2.4-GHz band, to sense all receivable vacant channels. The next step is to compare a receiving signal received by the dual-band antenna ANT1 with a receiving signal received by the dual-band antenna ANT2, and select one of the two communication systems by which a more desired signal is received, as an active communication system. After this scanning operation, the other antenna is connected to the transmitting/receiving means of the selected active transmitting/receiving apparatus to perform receiving without changing the receiving channel. The receiving signals from two antennas are compared, and an antenna capable of performing better receiving is selected as an active antenna to conduct diversity receiving.

[0005] In this multi-band communication apparatus, however, different antennas are connected in each communication system, a desired communication system is selected, and then an antenna to be used in this communication system is selected to conduct diversity receiving. In this scanning operation, disturbance such as phasing, etc. is not taken into account, resulting in the likelihood that a communication system in which a receiving signal has the largest amplitude is not selected. Accordingly,

the first object of the present invention is to provide a high-frequency circuit commonly usable in at least two communication systems, and capable of selecting a communication system by which the most desired signal is received as the active communication system to perform diversity receiving.

[0006] Also, because high-frequency signal paths should be switched by many switch means in the conventional multi-band communication apparatus, control becomes complicated depending on the number of switch means. Because the switch means have transmission loss to some extent, many switch means disposed in paths from antennas to transmitting/receiving means increase transmission loss according to their number. Particularly at the time of receiving, the quality of a high-frequency signal input through an antenna is disadvantageously deteriorated. In addition, because power consumed by switching means is not negligible in battery-driven equipments such as note PCs, cell phones, etc., it has been requested to constitute a multi-band high-frequency circuit with few numbers of switch means. The second object of the present invention is to provide a high-frequency circuit capable of switching the connection of multi-band antennas to transmitting circuits and receiving circuits with a few switch means.

[0007] High-frequency circuits for WLAN also need filter circuits for removing unnecessary frequency components contained in transmission signals and receiving signals, in addition to switch circuits for switching diversity switches, transmitting circuits and receiving circuits. Further, balanced-to-unbalanced converters for converting balanced signals to

unbalanced signals, and impedance-converting circuits are needed. The third object of the present invention is to provide a high-frequency circuit comprising a filter circuit, a balanced-to-unbalanced converter and an impedance-converting circuit.

[0008] When contained in cell phones or note PCs, or used as network cards of PCMCIA (personal computer memory card international association), it is strongly desired to miniaturize the high-frequency circuit of the present invention. The fourth object of the present invention is to provide a high-frequency circuit component comprising the above high-frequency circuit in a small three-dimensional laminate structure.

[0009] The fifth object of the present invention is to provide a multi-band communication apparatus comprising a transmitting/receiving means for modulating transmission data and demodulating receiving data in each communication system, and a switch circuit controller for controlling the switching of the high-frequency switches.

## DISCLOSURE OF THE INVENTION

[0010] The first invention is a high-frequency circuit sharable among at least two communication systems, the high-frequency circuit comprising pluralities of multi-band antennas capable of transmitting and receiving in communication systems having different communication frequencies; a high-frequency switch comprising four ports for switching the connection of the pluralities of multi-band antennas and transmitting/receiving circuits; a first diplexer circuit disposed between one port of the high-frequency switch and the transmitting circuit; and a second diplexer circuit disposed

between another port of the high-frequency switch and the receiving circuit. The high-frequency circuit of this invention preferably comprises a first filter circuit disposed between the second diplexer circuit and a first receiving circuit; a first balanced-to-unbalanced converter connected to the first filter circuit; a second filter circuit disposed between the second diplexer circuit and a second receiving circuit; and a second balanced-to-unbalanced converter connected to the second filter circuit.

[0011] Also, the high-frequency circuit of this invention preferably comprises a matching circuit disposed between the first filter and the first balanced-to-unbalanced converter and/or between the second filter and the second balanced-to-unbalanced converter. The first filter is preferably a highpass filter or bandpass filter, and the second filter is preferably lowpass filter circuit, a combination of a highpass filter circuit and a lowpass filter circuit, or a bandpass filter circuit.

[0012] The second invention is a laminate, high-frequency circuit component comprising the high-frequency circuit of this invention, the laminate, high-frequency circuit component comprising a first diplexer circuit, a second diplexer circuit, a first filter circuit, a second filter circuit, a first balanced-to-unbalanced converter and a second balanced-to-unbalanced converter, which mainly comprise inductance elements and capacitance elements, wherein at least part of inductance elements and capacitance elements is constituted by the electrode patterns formed in a laminate. The high-frequency circuit component may comprise a high-frequency switch mainly comprising switching elements; a first diplexer circuit mainly comprising inductance elements and

capacitance elements; a second diplexer circuit; a first filter circuit; a second filter circuit; a first balanced-to-unbalanced converter; and a second balanced-to-unbalanced converter; the switching elements is mounted onto the laminate, among circuit elements constituting the high-frequency circuit.

[0013] The third invention is a multi-band communication apparatus comprising the high-frequency circuit of the present invention, the multi-band communication apparatus comprising a transmitting/receiving means for modulating transmission data and demodulating receiving data in each communication system, and a switch circuit controller for controlling the switching of the high-frequency switches.

EFFECT OF THE INVENTION

[0014] The multi-band high-frequency circuit of the present invention can select a communication system by which the most suitable signal is received as an active communication system to perform diversity receiving in data communications by WLAN, and perform diversity receiving. The multi-band high-frequency circuit of the present invention can also switch the connection of the multi-band antennas and transmitting circuits/receiving circuits while suppressing power consumption with few numbers of switch means. With a high-frequency circuit component having the above high-frequency circuit in a small three-dimensional laminate structure, it is possible to provide a multi-band communication apparatus with a transmitting/receiving means for modulating transmission data and demodulating receiving data in each communication system, and a

switch circuit controller for controlling the switching of the high-frequency switch. The multi-band high-frequency circuit of the present invention having such features is suitable for personal computers, PC peripherals such as printers, hard disk drives, broadband rooters, etc.; electronic appliances such as facsimiles, refrigerators, standard-definition televisions (SDTV), high-definition televisions (HDTV), digital cameras, digital video recorders, cell phones, etc.; and signal-transmitting means in automobiles and aircrafts in place of wire.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Fig. 3 shows the circuit of the multi-band communication apparatus according to an embodiment of the present invention. The first communication system is IEEE802.11a, and the second communication system is IEEE802.11b, though the present invention is not particularly restricted thereto. For instance, because IEEE802.11g uses the same frequency band as IEEE802.11b as described above, each circuit may be used in each communication system. When both IEEE802.11b and IEEE802.11g are used, a transmitting/receiving means capable of handling each of them is necessary, because they need different modulation systems.

[0016] The multi-band communication apparatus according to this embodiment comprises two multi-band antennas ANT1, ANT2 transmittable and receivable in a 2.4-GHz band and a 5-GHz-band; a high-frequency circuit 1 comprising a high-frequency switch for switching the connection of the multi-band antennas and the transmitting circuits and receiving circuits; a transmitting/receiving circuit comprising a

transmitting/receiving means of IEEE802.11a and a transmitting/receiving means of IEEE802.11b for modulating transmission data and demodulating receiving data in each communication system, a switch circuit controller for controlling the switching of the high-frequency switch, and amplifiers for receiving signals; balanced-to-unbalanced converters 53, 54 for converting balanced signals to unbalanced signals; and amplifiers PA for transmission signals connected to the balanced-to-unbalanced converters. In another embodiment, the transmitting/receiving circuit may comprise the balanced-to-unbalanced converters 53, 54, the amplifiers PA for transmission signals, and coupling circuits.

[0017] Fig. 1 shows the circuit of one example of the high-frequency circuit 1. A double-pole, double-throw (DPDT) switch circuit 10 is disposed in the rear of the first multi-band antenna ANT1 and the second multi-band antenna ANT2. This switch circuit 10 has four ports. A first port 10a is connected to the first multi-band antenna ANT1. A second port 10b is connected to the second multi-band antenna ANT2. A third port 10c is connected to a first diplexer circuit 20 on the side of the transmitting circuit, and a fourth port 10d connected to a second diplexer circuit 25 on the side of the transmitting/receiving circuits.

[0018] The first diplexer circuit 20 is constituted by a combination of a lower-frequency filter circuit permitting a high-frequency signal in a 2.4-GHz band (IEEE802.11b) to pass but attenuating a high-frequency signal in a 5-GHz band (IEEE802.11a), and a higher-frequency filter circuit permitting a high-frequency signal in a 5-GHz band (IEEE802.11a) to pass but attenuating a transmission signal in a 2.4-GHz band (IEEE802.11b).

Accordingly, a 2.4-GHz-band, high-frequency signal input from the transmitting circuit of IEEE802.11b to the second port 20b of the first diplexer circuit appears at the first port 20a via the lower-frequency filter circuit, but not at the third port 20c. On the other hand, a 5-GHz-band, high-frequency signal input from the transmitting circuit of IEEE802.11a to the third port 20c of the first diplexer circuit appears at the first port 20a via the higher-frequency filter circuit, but not at the second port 20b. The high-frequency signal appearing at the first port 20a is input to the third port 10c of the switch circuit.

[0019] As is the case with the first diplexer circuit 20, the second diplexer circuit 25 is constituted by a combination of a filter circuit permitting a high-frequency signal in a 2.4-GHz band (IEEE802.11b) to pass but attenuating a high-frequency signal in a 5-GHz band (802.11a), and a filter circuit permitting a high-frequency signal in a 5-GHz band (IEEE802.11a) to pass but attenuating a transmission signal in a 2.4-GHz band (IEEE802.11b). With such structure, among high-frequency signals input into the first multi-band antenna ANT1 or the second multi-band antenna ANT2 and appearing at the fourth port 10d of the switch circuit 10, a 2.4-GHz-band, high-frequency signal appears at the second port 25b of the second diplexer circuit, but not at the third port 25c, and a 5-GHz-band, high-frequency signal appears at the third port 25c of the second diplexer circuit, but not at the second port 25b.

[0020] The high-frequency signal appearing at its second port 25b is input to the receiving circuit of IEEE802.11b via a filter circuit 30 and a balanced-to-unbalanced converter 50. Also, the high-frequency signal

appearing at the third port 25c is input to the receiving circuit of IEEE802.11a via a filter circuit 40 and a balanced-to-unbalanced converter 55. The first and second diplexer circuits 20, 25 are constituted by proper combinations of lowpass filter circuits, highpass filter circuits and notch filter circuits comprising inductance elements and capacitance elements. The equivalent circuits are exemplified in Figs. 8-10. Filter circuits 30, 40 are also constituted by lowpass filter circuits, highpass filter circuits or bandpass filter circuits. These filter circuits are properly selected by the off-band attenuation of the diplexer circuits 20, 25. The equivalent circuits of the filter circuit 30, 40 are exemplified in Figs. 11 and 12. The balanced-to-unbalanced converters 50, 55 are constituted by inductance elements and capacitance elements, and may have an impedance-converting function. Their equivalent circuits are exemplified in Figs. 13 and 14. The filter circuits and the balanced-to-unbalanced converters may be constituted by an unbalanced input-balanced output SAW filter.

[0021] Figs. 4-76 shows examples of the equivalent circuits of the switch circuit 10. These switch circuit 10 are mainly constituted by switching elements such as field-effect transistors (FETs), diodes, etc., and may comprise inductance elements and capacitance elements.

[0022] Diversity receiving performance on a case where the switch circuit shown in Fig. 4 is used will be explained below. When voltage controlled by this switch circuit controller is applied to the control terminals V1, V2, the ports are connected as shown in Table 1.

[0023] Table 1

| Connection Mode | V1 | V2 | Between Ports 10a and 10c | Between Ports 10a and 10d | Between Ports 10b and 10c | Between Ports 10b and 10d |
|---|---|---|---|---|---|---|
| 1 | High | Low | Connected | Disconnected | Disconnected | Connected |
| 2 | Low | High | Disconnected | Connected | Connected | Disconnected |

[0024] When diversity receiving is conducted, frequency scanning is first conducted before starting communications to sense a receivable frequency channel. In the scanning operation, the high-frequency switch circuit 10 is controlled, for instance, to the connection mode 1 shown in Table 1 by the switch circuit controller. In this case, the second multi-band antenna ANT2 is connected to the second diplexer circuit 25, resulting in the connection of one multi-band antenna to the receiving circuits of two communication systems. Scanning is performed in a 5-GHz band in the receiving circuit of IEEE802.11a, and in a 2.4-GHz band in the transmitting/receiving means of 802.11b, to sense all receivable channels.

[0025] Next, the switch circuit 10 is controlled to a connection mode 2 by the switch circuit controller. At this time, the first multi-band antenna ANT1 is connected to the second diplexer circuit 25 on the receiving circuit side. Based on the resultant high-frequency signal, scanning is performed in a 5-GHz band in the receiving circuit of IEEE802.11a, and in a 2.4-GHz band in the transmitting/receiving means of IEEE802.11b, to sense all receivable channels.

[0026] Based on the results of frequency scanning, receiving signals received by the first and second dual-band antennas ANT1, ANT2 are compared in amplitude, and selected as an active communication system,

as well as to select an antenna to be connected to the transmitting/receiving circuit of the communication system. Accordingly, the most suited communication system can be selected even with disturbance such as phasing, etc. to conduct diversity receiving.

[0027] The second multi-band antenna ANT2 is connected to the second diplexer circuit 25 on the receiving circuit side, and scanning is performed in a 5-GHz band. At this time, scanning is performed in a 2.4-GHz band to sense all receivable channels. The received signals are compared in amplitude to select one communication system and the transmitting/receiving circuit is turned to be active, the first multi-band antenna ANT1 is connected to the selected active transmitting/receiving circuit without changing the receiving channel. The receiving signals from two antennas are compared, and an antenna capable of performing better receiving is selected as an active antenna to conduct diversity receiving.

[0028] The high-frequency circuit of the present invention formed by a ceramic laminate is explained blow. Fig. 15 is a perspective view showing the appearance of a high-frequency circuit component comprising a filter module formed in a laminate. Figs. 16 and 17 is an expanded view showing the structure of each layer in the laminate 100 constituting the high-frequency circuit component. Fig. 2 shows the equivalent circuit of the high-frequency circuit component. The laminate 100 is produced by laminating pluralities of ceramic green sheets as thick as 10-200 μm and made of, for instance, a dielectric ceramic sinterable at as low a temperature as 1000°C or lower, each of which is provided with an

electrode pattern formed by printing a low-resistive, conductive paste of Ag, Cu, etc., and integrally sintering them. Dielectric materials may be, for instance, a material comprising Al, Si and Sr as main components, and Ti, Bi, Cu, Mn, Na, K, etc. as sub-components; a material comprising Al, Si and Sr as main components, Ca, and Pb, Na, K, etc. as sub-components; a material comprising Al, Mg, Si and Gd; or a material comprising Al, Si, Zr and Mg. The dielectric materials have dielectric constants of about 5-15. Besides the dielectric ceramics, resins and resin/ceramic composite materials may be used. Further, transmission lines, etc. may be formed by high-temperature-sinterable metal conductors such as tungsten, molybdenum, etc. on $Al_2O_3$-based dielectric substrates, by a high-temperature cofirable ceramic (HTCC) technology.

[0029] A lowermost green sheet 15 is covered with a ground electrode GND on its front surface, and provided with terminal electrodes for mounting to a circuit substrate on its rear surface. The terminal electrodes comprise antenna ports ANT1, ANT2, transmission ports Tx1, Tx2, receiving ports Rx1+, Rx1-, Rx2+, Rx2-, ground ports GND, and switch circuit-controlling ports V1, V2, and these ports are connected to electrode patterns on green sheets above through via-holes (shown by black circles in the figure) formed in the green sheets. In this embodiment, the terminal electrodes in a land grid array (LGA), but may be in a ball grid array (BGA), etc.

[0030] Green sheets 1-14 are laminated on the green sheet 15. On these green sheets, the first and second diplexer circuits 20, 25, the filter circuits 30, 40, 60, and the balanced-to-unbalanced converters 50, 55 are

constituted by inductance elements and capacitance elements formed by predetermined electrode patterns, which are properly connected through via-holes. Matching circuits 80, 85 disposed between the filter circuits 30, 40 and the balanced-to-unbalanced converters 50, 55 are formed by transmission lines having predetermined length.

[0031] Each circuit is three-dimensionally formed in the laminate, and electrode patterns constituting the circuits are disposed such that they are separated by the ground electrode GND or do not overlap in a lamination direction, to prevent unnecessary electromagnetic interference.

[0032] Pluralities of land electrodes are formed on a green sheet 1, and DPDT switches (GaAs FETs), and coupling capacitors that cannot be formed in the laminate are mounted as chip parts onto the land electrodes. The land electrodes are connected to connecting lines and circuit elements in the laminate through via-holes.

[0033] Bare switches are mounted onto the land electrodes, and the land electrodes may be sealed by resins or pipes. Such multi-band high-frequency circuit components are suitably miniaturized. Incidentally, RF-ICs or base-band ICs constituting the transmitting/receiving circuits may be integrated to the laminate.

APPLICABILITY IN INDUSTRY

[0034] The multi-band high-frequency circuit of the present invention can select a communication system by which the most suitable signal is received as an active communication system to perform diversity receiving in data communications by WLAN, and perform diversity receiving. The

multi-band high-frequency circuit of the present invention can also switch the connection of the multi-band antennas and transmitting circuits/receiving circuits while suppressing power consumption with few numbers of switch means. With a high-frequency circuit component having the above high-frequency circuit in a small three-dimensional laminate structure, it is possible to provide a multi-band communication apparatus with a transmitting/receiving means for modulating transmission data and demodulating receiving data in each communication system, and a switch circuit controller for controlling the switching of the high-frequency switch. The multi-band high-frequency circuit of the present invention having such features is suitable for personal computers, PC peripherals such as printers, hard disk drives, broadband rooters, etc.; electronic appliances such as facsimiles, refrigerators, standard-definition televisions (SDTV), high-definition televisions (HDTV), digital cameras, digital video recorders, cell phones, etc.; and signal-transmitting means in automobiles and aircrafts in place of wire.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] Fig. 1 is a block diagram showing the high-frequency circuit according to one embodiment of the present invention.

[0036] Fig. 2 is a view showing the equivalent circuit of the high-frequency circuit according to one embodiment of the present invention.

[0037] Fig. 3 is a block diagram showing the circuit of the multi-band communication apparatus according to one embodiment of the present

invention.

[0038] Fig. 4 is a view showing the equivalent circuit of one example of DPDT switches used in the present invention.

[0039] Fig. 5 is a view showing the equivalent circuit of another example of DPDT switches used in the present invention.

[0040] Fig. 6 is a view showing the equivalent circuit of a further example of DPDT switches used in the present invention.

[0041] Fig. 7 is a view showing the equivalent circuit of a still further example of DPDT switches used in the present invention.

[0042] Fig. 8 is a view showing the equivalent circuit of one example of diplexer circuits used in the present invention.

[0043] Fig. 9 is a view showing the equivalent circuit of another example of diplexer circuits used in the present invention.

[0044] Fig. 10 is a view showing the equivalent circuit of another example of diplexer circuits used in the present invention.

[0045] Fig. 11 is a view showing the equivalent circuit of one example of filter circuits used in the present invention.

[0046] Fig. 12 is a view showing the equivalent circuit of another example of filter circuits used in the present invention.

[0047] Fig. 13 is a view showing the equivalent circuit of one example of balanced-to-unbalanced circuits used in the present invention.

[0048] Fig. 14 is a view showing the equivalent circuit of another example of balanced-to-unbalanced circuits used in the present invention.

[0049] Fig. 15 is a perspective view showing a high-frequency circuit component according to one embodiment of the present invention.

[0050] Fig. 16 is an exploded perspective view showing laminate substrates used in the present invention.

[0051] Fig. 17 is an exploded perspective view showing laminate substrates used in the present invention.

[0052] Fig. 18 is a block diagram showing a conventional multi-band communication apparatus.

ABSTRACT OF THE DISCLOSURE

OBJECT

The present invention provides a high-frequency circuit sharable among at least two communication systems and capable of performing diversity receiving, a high-frequency component and a multi-band communication apparatus using the same.

CONSTRUCTION

Comprised are pluralities of multi-band antennas capable of transmitting and receiving in communication systems having different communication frequencies; a high-frequency switch comprising four ports for switching the connection of said pluralities of multi-band antenna and transmitting/receiving circuits; a first diplexer circuit disposed between one port of said high-frequency switch and said transmitting circuit; and a second diplexer circuit disposed between another port of said high-frequency switch and said receiving circuit.

SELECTED DRAWING

Fig. 1

WHAT IS CLAIMED IS:

1. A high-frequency circuit sharable among at least two communication systems, said high-frequency circuit comprising:

pluralities of multi-band antennas capable of transmitting and receiving in communication systems having different communication frequencies;

a high-frequency switch comprising four ports for switching the connection of said pluralities of multi-band antennas and transmitting/receiving circuits;

a first diplexer circuit disposed between one port of said high-frequency switch and said transmitting circuit; and

a second diplexer circuit disposed between another port of said high-frequency switch and said receiving circuit.

2. The high-frequency circuit according to claim 1, further comprising:

a first filter circuit disposed between said second diplexer circuit and a first receiving circuit;

a first balanced-to-unbalanced converter connected to said first filter circuit;

a second filter circuit disposed between said second diplexer circuit and a second receiving circuit; and

a second balanced-to-unbalanced converter connected to said second filter circuit.

3. The high-frequency circuit according to claim 2, further comprising a matching circuit disposed between said first filter and said

first balanced-to-unbalanced converter and/or between said second filter and said second balanced-to-unbalanced converter

4. The high-frequency circuit according to claim 1 or 2; wherein said first filter is a highpass filter or a bandpass filter circuit; and wherein said second filter is a lowpass filter circuit, a combination of a highpass filter circuit and a lowpass filter circuit, or a bandpass filter circuit.

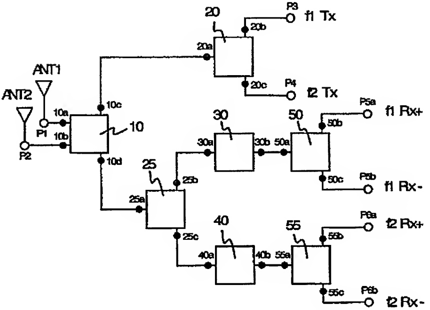
5. A laminate, high-frequency circuit component comprising the high-frequency circuit recited in any one of claims 1-4, said laminate, high-frequency circuit component comprising a first diplexer circuit, a second diplexer circuit, a first filter circuit, a second filter circuit, a first balanced-to-unbalanced converter and a second balanced-to-unbalanced converter, which mainly comprise inductance elements and capacitance elements, wherein at least part of inductance elements and capacitance elements is constituted by said electrode patterns formed in a laminate.

6. The high-frequency circuit component according to claim 5, wherein at least a high-frequency switch mainly comprising switching elements is mounted onto said laminate.

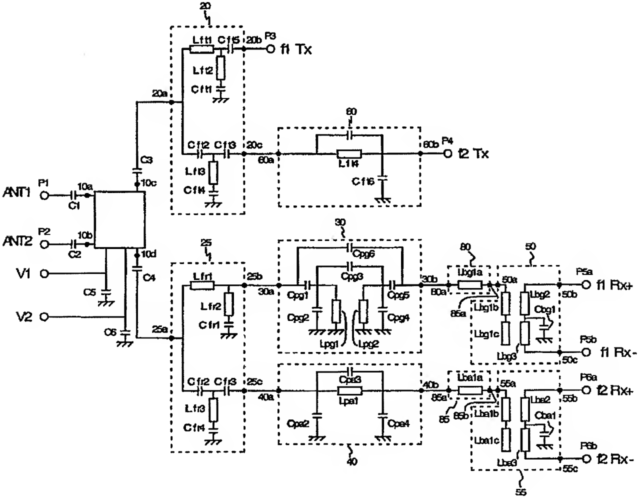
7. A multi-band communication apparatus comprising the high-frequency circuit recited in any one of claims 1-6, said multi-band communication apparatus comprising a transmitting/receiving means for modulating transmission data and demodulating receiving data in each communication system, and a switch circuit controller for controlling the switching of said high-frequency switches.

# Drawings

## Fig. 1

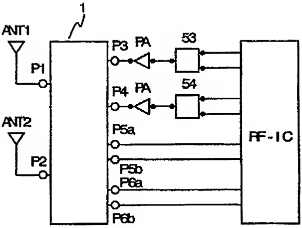



## Fig. 2

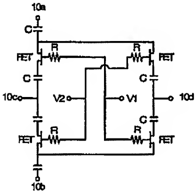


Japanese Patent Application No. 2003-413623

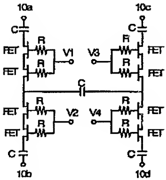
# Fig. 3



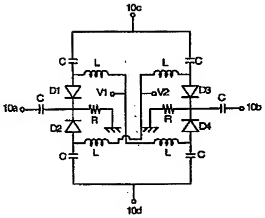

# Fig. 4



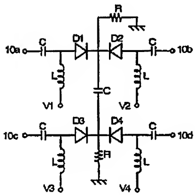

# Fig. 5



# Fig. 6




# Fig. 7




# Fig. 8

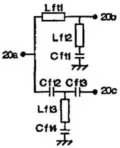


Fig. 9

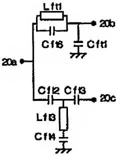



Fig. 10

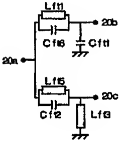



Fig. 11

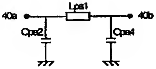
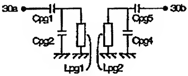
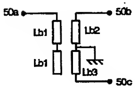


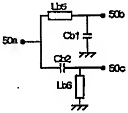

Fig. 12



# Fig. 13




# Fig. 14

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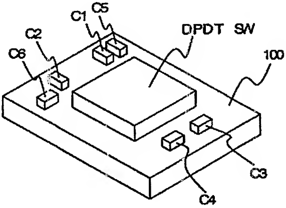

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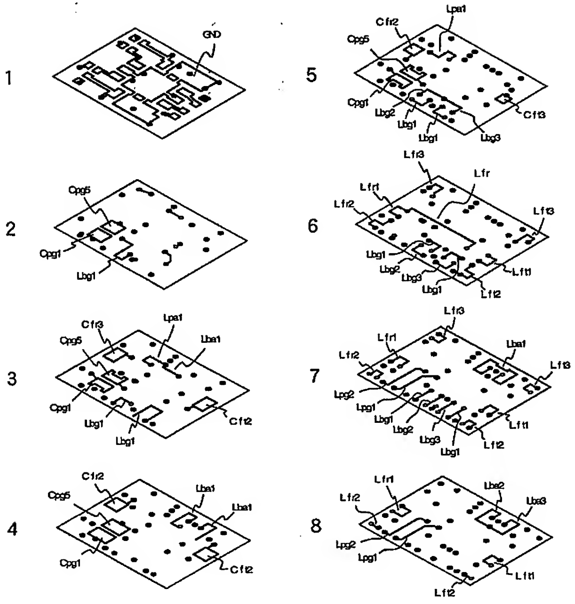
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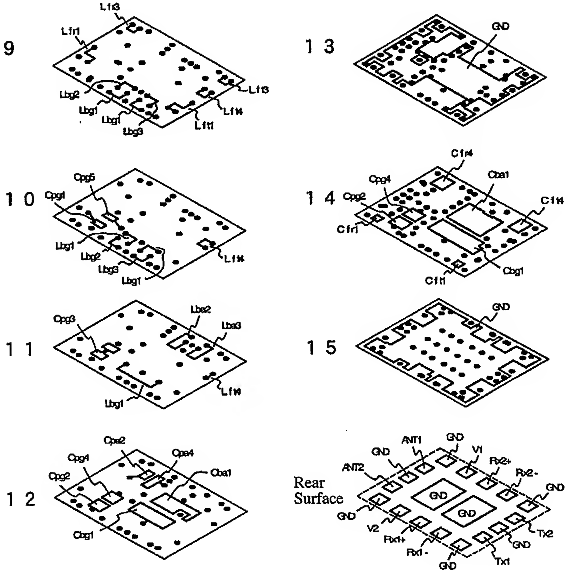
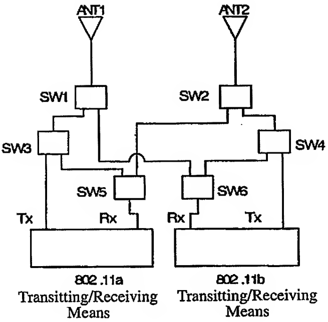
# Fig. 17



# Fig. 18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